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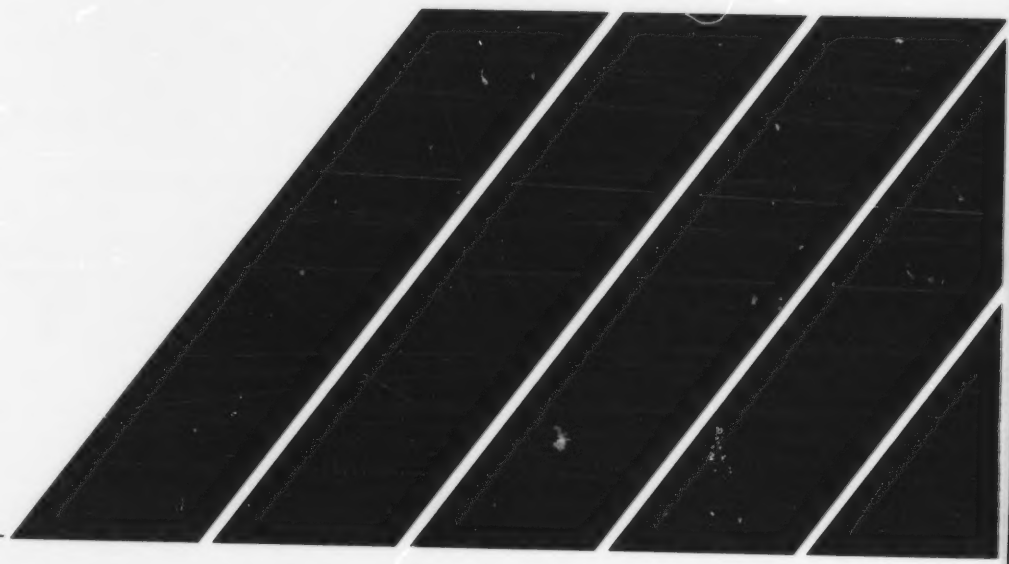
ELECTROMAGNETIC INTERFERENCE OF A LARGE VERTICAL AXIS WIND TURBINE



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ELECTROMAGNETIC INTERFERENCE OF A LARGE VERTICAL AXIS WIND TURBINE

PREPARED FOR:

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PREPARED BY:

Curtis Gavin
Institute of Man and Resources
Atlantic Wind Test Site
P.O. Box 414, 92½ Queen Street
Charlottetown, P.E.I.
C1A 7K7
(902) 882-2746

SCIENTIFIC AUTHORITY:

Monique Carpentier
Efficiency and Alternative Energy Technology Branch
Energy, Mines and Resources Canada
580 Booth Street
Ottawa, Ont.
K1A 0E4

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ABSTRACT

The effect on television reception in the immediate vicinity of a large vertical axis wind turbine is investigated through observation and recording television images transmitted from both a nearby and distant transmitting towers. Although distinguishable effects are observed, it was found that most effects can be eliminated by selecting antenna location and directional orientation.

RÉSUMÉ

Les effets de la présence d'une grande éolienne à axe vertical sur la qualité de réception des émissions de télévision dans les maisions situées dans le voisinage, ont fait l'objet d'une étude. Celle-ci à consisté à observer et enregistrer des images télévisées transmises par deux tours de transmission, l'une située loin des maisons et l'autre, à courte distance. Bien que certains effets aient pu être décelés, l'étude porte à conclure qu'un choix judicieux de l'emplacement de son antenne et de son orientation permet d'éliminer la plupart de ces effets.

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ELECTROMAGNETIC INTERFERENCE OF A LARGE VERTICAL AXIS WIND TURBINE

Curtis Gavin
Atlantic Wind Test Site
North Cape, Prince Edward Island

INTRODUCTION

Interference to broadcast television reception caused by wind turbines is one of the few possible negative effects of installing and operating wind turbines near inhabited areas where television reception is obtained using conventional TV antennas. This report describes a qualitative investigation of the effect on nearby television reception of a large vertical axis wind turbine (VAWT) at the Atlantic Wind Test Site (AWTS).

It is often considered apparent that television interference caused by wind turbines would be greatest in one or combinations of the following circumstances:

1. for machines with metal blades;
2. for large machines;
3. at frequencies where dimensions of the wind turbine blades and tower structure are the same order of magnitude as the signal wave length;
4. where a wind turbine is near a receiver;
5. where a wind turbine is near to the source of signal transmission; and
6. for certain azimuth positions of the rotor blades.

Electromagnetic waves are the means by which television, AM and FM radio and other radio communication signals are transmitted through space. Like their close relatives, light and sound, they are reflected, refracted, absorbed and dispersed by the medium through which they travel and obstructions or objects in their path. In general the nature and degree of effect of the path properties is dependent upon the wave length (frequency) of the signal relative to the dimensions and materials of the path and objects in the path.

Television interference assessment or the effect on television signal transmission is not measured simply as a loss or reduction in signal strength at the receiver but must be established in terms of viewer enjoyment and other such factors which are difficult to quantify. For example, from previous investigations of horizontal axis wind turbines almost no discernable interference was found to occur to broadcast AM or FM radio transmissions. There is evidence[1] however that television signals, particularly the higher VHF and UHF channels,

can be adversely affected. This is due to the sensitivity of both the receiver and the viewer to aberrations in the signal and display.

The video portion of a TV signal is AM modulated and picture elements are dependent upon instantaneous signal strength. Color receivers are more prone to disturbance than are black and white receivers since changes in signal strength can cause color miscuing as well as image quality and clarity. Picture stability, which is dependent on horizontal and vertical synchronizing pulse signal accuracy will also be adversely affected if the presence or quality of these pulses is affected by the properties of the signal path.

Interference by objects in the signal path may result from both direct signal obstruction and from reflection from objects along the path which allow multi-path transmissions to reach the receiver. Because multi-path signals differ in time, phase, and amplitude there may be very negative effects on the quality of a received television signal. The effect may be observed as multiple imaging or 'ghosting' as it is often referred to.

Investigation of ghosting effects on television images is often required when a television station or network wishes to install new towers and transmitters. Reference (1) provides a description and the results of one such investigation carried out to evaluate television signal reflections occurring as a result of relocation of a new tower and transmitter.

In the case of moving objects such as wind turbines the interference caused by multi-path reflections may be cyclical and not cause just stationary ghosting but a dynamic distortion or modulation of video image that is most disturbing to viewer enjoyment.

The nature and degree of interference caused to television reception by objects such as wind turbines, communication towers, transmission line towers and other such structures cannot be easily quantified and usually must be determined by very empirical analysis or practical measurement.

The general mechanisms by which a windmill may produce undesirable interference effects on television reception is described in terms of the general equations for combined FM and AM modulated television signals in Reference (2). Although this reference considers only horizontal axis wind turbines, discussion of the scattering and signal modulation caused by a wind turbine is sufficiently general to allow interpretation to both horizontal and vertical axis machines with some consideration to the obvious differences in geometry.

The subject of interference to telecommunication signals from wind turbines has not been researched and investigated to a great extent. As the technology gains wider application there will undoubtedly be more interest in this issue. For further information on considerations of the problem and experiences with interference measurements the reader is referred to the bibliography.

This report provides results of measurement and observation of the influence on nearby television reception of a 500 kW VAWT of the Darrieus type located at the AWTS in Prince Edward Island, Canada. The work was carried out on behalf of the Department of Energy, Mines and Resources as an element of a measurement program to evaluate operational and structural dynamic performance of this machine.

SCOPE

The scope of the investigation was limited to the visual observation of the effects on quality of video signal reception near the subject machine. Observations were made from a receiver located at positions around the machine. A portable antenna, receiver and recording package was used to enable quick relocation of the measurement apparatus to selected observation positions.

TEST PROCEDURE

The location of television transmitter towers providing television programming to the area was determined from television service contour maps obtained from the Department Communications office in Charlottetown. Two transmitter towers were selected based on their geographical location relative to AWTS. The first tower, which provides Grade B signal to AWTS on channels 4 and 5 was located at St. Edwards about 25 km distant from AWTS. The second tower located at Bonshaw provides somewhat less than Grade B signal on channel 13 and is 130 km from AWTS. Figures 1-4 illustrate the location of the AWTS and the towers.

Seven test locations were selected surrounding the wind turbine. The sites were selected so that observations for similar relative orientations of the machine, transmitter, and receiver could be obtained for both transmission sources. Figure 5 illustrates the test positions and AWTS features.

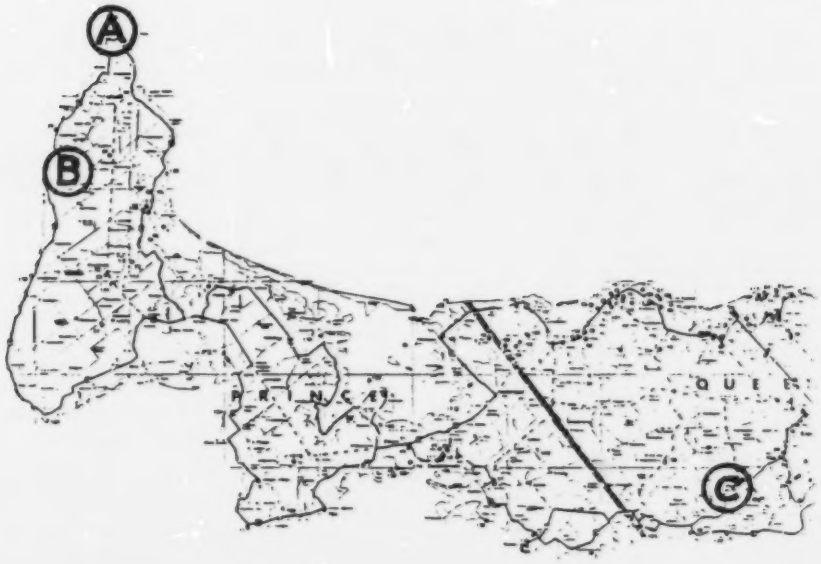

Figure 1. Location of Transmitters
A - Atlantic wind Test Site
B - Chanels 4 and 5
C - Channel 13

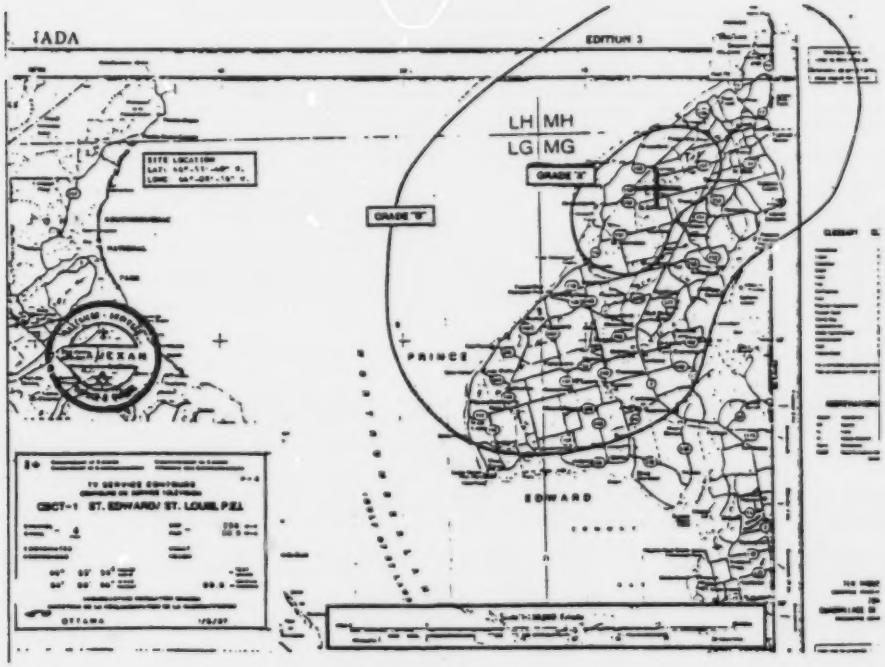

Figure 2. T.V. Service Contours for Channel 4

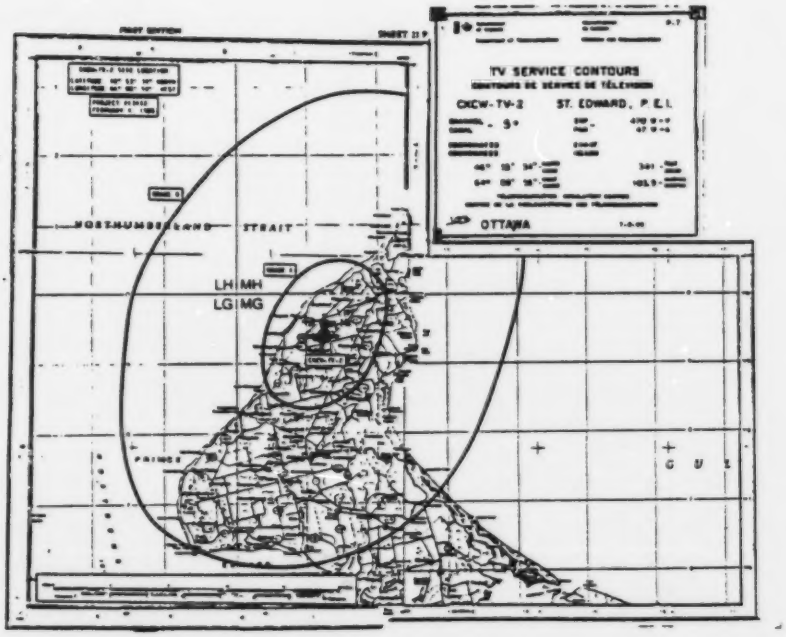

Figure 3. T.V. Service Contours for Channel 5

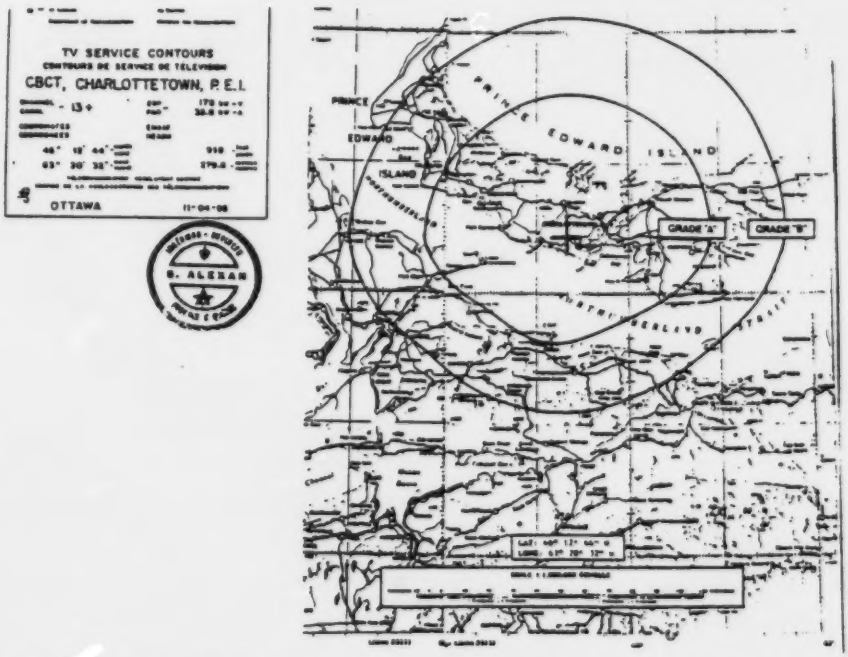

Figure 4. T.V. Service Contours for Channel 13

Figure 5. AWTS Site Plan and Observation Sites

The test apparatus used is illustrated in Figure 6.

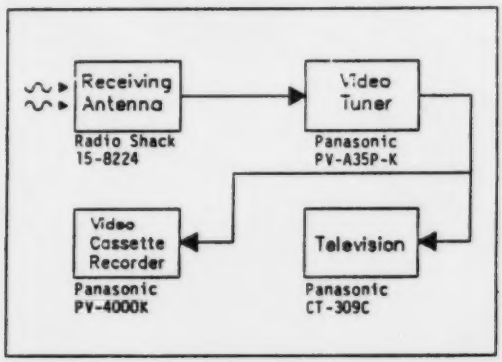

Figure 6. Observation and Recording Equipment

The antenna was mounted on a 12 m tower erected on a pick-up truck as illustrated in Figure 7.

Figure 7. Mobile Antenna Arrangement

The antenna direction could be adjusted easily from ground level. The receiver and recorder were powered from a small gasoline engine driven portable electrical generator which was positioned about 100 feet from the receiving and recording equipment during observations to avoid possible electromagnetic noise and interference caused by the engine ignition. The antenna used was a Radio Shack, 40 element, model 15-8224 with 60^{o} swept design VHF elements. The antenna is illustrated in Figure 8. This is a medium gain all band antenna intended for use in low to intermediate signal strength areas.

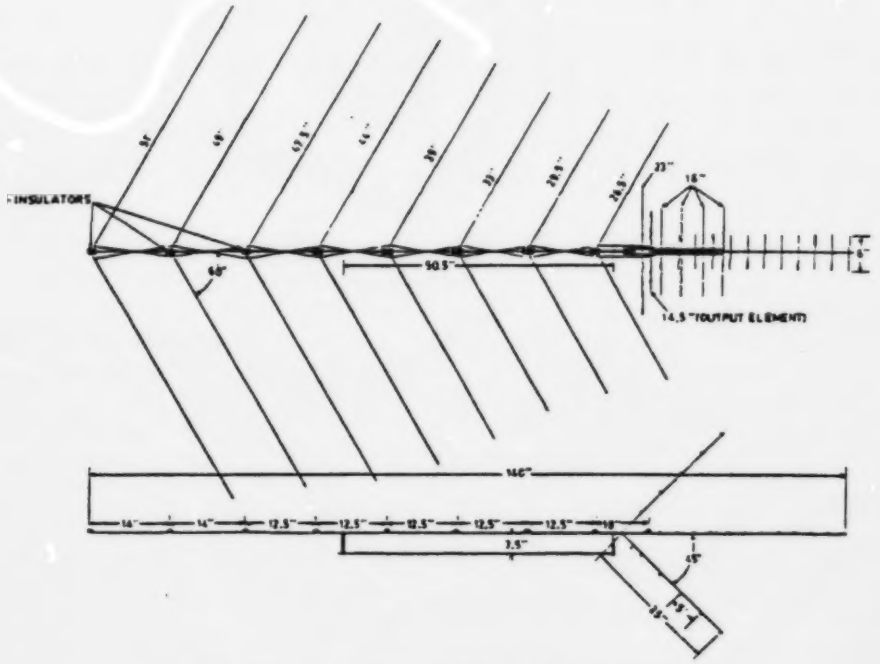

Figure 8. VHF UHF T.V. Antenna

The vertical axis wind turbine is illustrated in Figure 9.

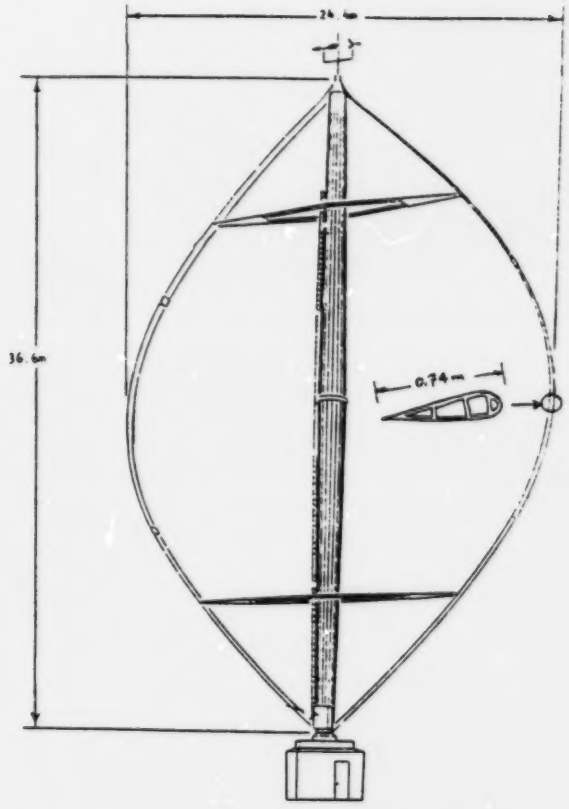

Figure 9. Indal Technologies 500 kW VAWT

The rotor blades are constructed of extruded aluminum with NACA 0015 profile having .74 m chord dimension. The rotor column is a double tapered 12 sided steel tube 1.5 m across at the center point and .75 m at each end. The rotor is 36 m long and its mid-point is located 22 m above the ground. When operating the rotor turns at 45 rpm. The wind turbine generates electricity with a 3 phase 600 V induction generator connected to the utility distribution lines through step up transformers. When operating near rated output the wind turbine impresses a 2-4% voltage fluctuation on the utility lines twice per revolution of the rotor. The possible effect of this mains voltage fluctuation on performance of the television receiver was avoided by the use of the portable generator to power the receiving equipment.

Prior to commencement of the testing program, discussions were held with the Department of Communications technical personnel in Charlottetown to review project objectives and proposed measurement and observation process. Conclusions reached during these discussions indicated that the subjective nature of the proposed investigation would probably be as conclusive as one attempting to make highly quantitative measurements of received signal strength, spectra or other signal parameters.

Discussions with Department of Communications technicians sparked an interest to conduct their own measurements on the influence of the wind turbine on television reception using a Vertical Interval Test Signal monitor (VITS) commonly employed by them to make such investigations. On July 14, 1988 when the equipment was available to them they performed a series of measurements to attempt to evaluate the interference and signal distortion created by the wind turbine. A summary report of their findings is attached as Appendix B.

METHODOLOGY

To make observations and to record data a series of procedures and information logging practices were developed. Figure 10 illustrates the observation data sheet employed to record specific test conditions and to make summary observations of receiver performance.

Observations were made both during early morning periods when a broadcast test pattern was available for viewing and also during periods of normal programming.

Although it would be clearly more desireable to be able to conduct observations using a specific test signal as was done in Reference 1, it was not possible to coordinate this during transmission periods for the stations selected.

Measurements were made at each location for operating and stationary condition of the wind turbine. A series of measurements was made with the receiver tuned to each of the three transmission signals. Each series of measurement consisted of observation of the received signal when the machine was stationary and operating and the antenna oriented for best reception. Observations were then made of the reflected signal from the rotor by directing the antenna towards the rotor. The final observation was made by adjusting direction of the antenna to obtain the highest level of interference with the machine operating. Each observation was recorded on video tape and an audio narration superimposed identifying the location, conditions and observations made.

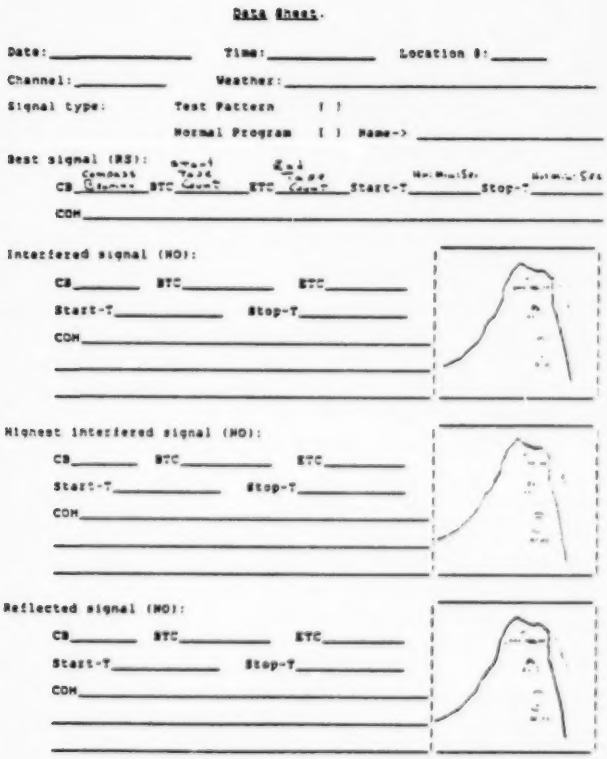

Figure 10. Field observation Data Sheet

OBSERVATION PROCEDURE

To minimize the number of set-ups required and the number of times that the wind turbine needed to be started and stopped, all observations for each antenna position, machine operation condition and for each transmitting station were conducted when a set up was made. By using one video tape for each channel the observations could be recorded in logical sequence for later viewing. The following describes the sequence of observation at a test location.

Observations consisted of monitoring three classes of signals: best, interferred and reflected. Best and interferred observations were made with the wind turbine stopped and at normal operating speed respectively. For each of these observations the antenna was pointed in the direction of the transmitting tower as illustrated in Figure 11.

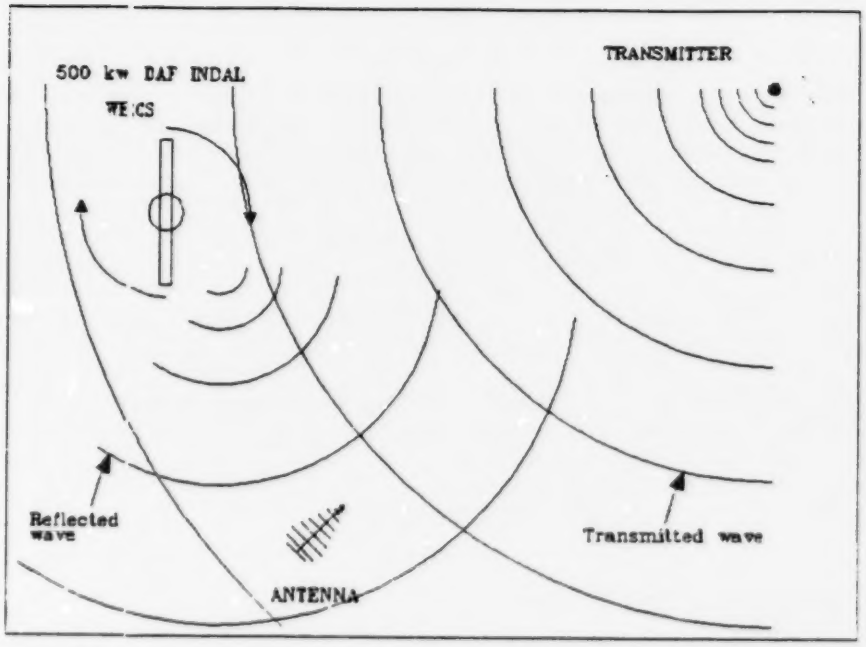

Figure 11. Antenna Orientation for Highest Quality Signal For Blades of WECS Stopped or Rotating

Reflected observations were made with the antenna pointing to the rotor as illustrated in Figure 12.

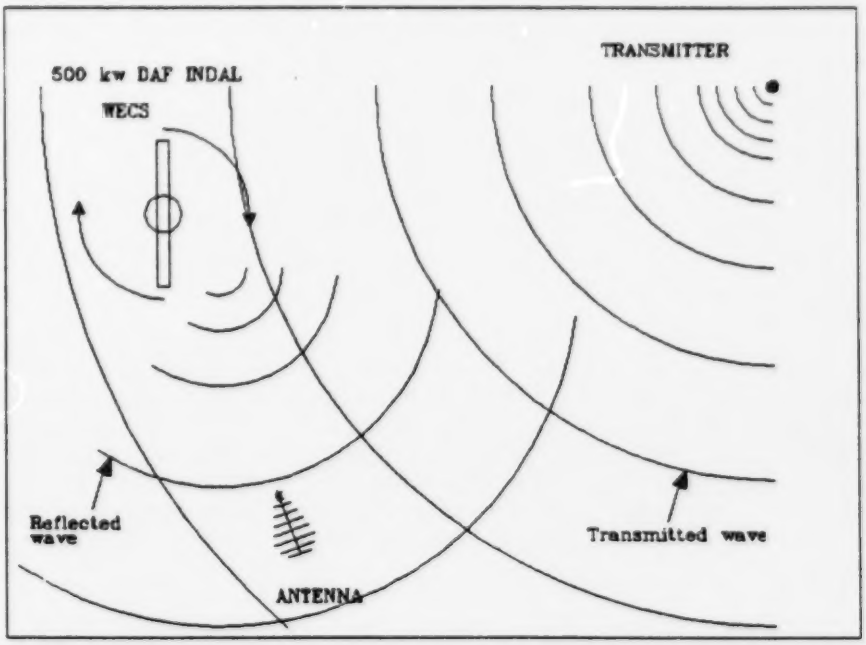

Figure 12. Antenna Orientation for Reflected Signals with Blades of WECS at Normal Operating Speed

The last observation is termed the highest interferred signal and was made with the wind turbine at normal operation with the antenna direction adjusted for the highest level of interference. The observations for the best signal with the rotor stopped was used as the reference for comparison with other observations. During each recording a narration was made identifying the recorded segment, direction of the antenna and a voice count sequence corresponding to each half revolution of the machine. The latter was done to enable more easy interpretation of results during review of the recordings.

During each observation the data sheet was completed describing conditions of the observation, identifying the recording tape segment by footage indication and making summary comment on the image quality. The completed data sheets are provided for reference in Appendix A.

ANALYSIS OF OBSERVATIONS

The recordings and data sheets were reviewed and observations classified according to the degree of interference observed relative to the best received signal. The interference most frequently observed was ghosting. The classification selected with regard to degree of ghosting were defined as Low, Medium and High occurrences. Low refers to a barely discernable incidence which does not interfere with viewer enjoyment. Medium was used to describe a definitely observable ghosting effect. High to a level of distortion that would be highly frustrating to the viewer.

Table 1 summarized the observations for each channel observed, machine operating status, signal observed, and receiver location. Blanks in the table indicate that the station was off air or a recording was not made.

Table 2 is a further summary prepared after reviewing and analyzing the recorded observations following the field observations.

There was a marked decrease in the ability to identifying defects in picture quality in the video tape as compared to the live observations. This is considered to be a result of the apparent loss of resolution occurring during video taping and replay. It can be seen however that there is some reasonable correlation between the levels of ghosting observed during field tests and that which could be discerned from the recorded images.

Analysis of the observations and the incidence of high image deterioration does not result in many conclusions that are strongly confirmed by the data. There is however indication that the most observable picture degradation occurs for the reflected

TABLE 1

Summary of Data Sheets
Levels of Ghosting: Low, Medium, High

CHANNEL 4

Location	1	2	3	4	5	6	7
Best Signal (RS)	-	L	-	L	L	L	L
Reflected Signal (RS)	-	L	-	-	-	-	L
Interfered Signal (NO)	-	M	M	M	L	L	L
Reflected Signal (NO)	-	M	_	-	-	H	L

CHANNEL 5

Location	1	2	3	4	5	6	7
Best Signal (RS)	L	L	L	L	L	H	L
Reflected Signal (RS)	H	-	M	H	H	L	H
Interfered Signal (NO)	M	L	L	L	L	L	L
Reflected Signal (NO)	H	L	M	H	H	H	H

CHANNEL 13

Location	1	2	3	4	5	6	7
Best Signal (RS)	L	L	L	L	L	L	L
Reflected Signal (RS)	L	L	L	H	H	L	H
Interfered Signal (NO)	L	L	M	L	L	L	L
Reflected Signal (NO)	L	L	-	H	H	H	H

TABLE 2

Summary of Data Sheets
Distortion: Definite, None

CHANNEL 4

Location	1	2	3	4	5	6	7
Best Signal (RS)	-	N	-	N	N	-	-
Reflected Signal (RS)	-	N	-	-	-	-	N
Interfered Signal (NO)	-	N	-	N	N	-	N
Reflected Signal (NO)	-	D	-	-	-	D	D

CHANNEL 5

Location	1	2	3	4	5	6	7
Best Signal (RS)	N	N	N	N	N	N	N
Reflected Signal (RS)	N	N	N	N	N	N	N
Interfered Signal (NO)	N	N	-	N	N	N	N
Reflected Signal (NO)	D	N	N	D	D	D	D

CHANNEL 13

Location	1	2	3	4	5	6	7
Best Signal (RS)	N	N	N	N	N	N	N
Reflected Signal (RS)	N	N	N	N	N	N	N
Interfered Signal (NO)	N	N	N	N	N	N	N
Reflected Signal (NO)	N	N	D	D	D	D	D

signal measurement observations obtained when the antenna is aimed directly at the rotor thus indicating that the rotor when both parked and rotating does cause some scatter of the transmitted signal. This must not be construed however as a potential problem since it represents a non-typical situation with the receiver antenna aimed not at the source of programming but instead at the wind turbine.

The occurrence of medium levels of interference as the result of multi-path and direct in-line obstruction are found to be generally of low effect. Only a few instances of medium level effects were observed which became nondiscernable upon later viewing of the video tape. The obvious worse case scenario anticipated when the wind turbine rotor is located directly between the transmitter and the receiver is not confirmed

reliably by the observations. The scope of the observations did not, however, allow for a more thorough investigation and to perform many additional observations which would be required to more fully investigate this effect.

CONCLUSIONS

Analysis of the observations indicates that there are definite multiple-path images caused by the wind turbine which appear to be due to multiple-path reflections. Recordings of channel 5 at locations 4 and 6 and also channel 13 at locations 5 and 6 provide examples of this. The worst interference was observed only when the antenna was pointed directly at the wind turbine. Observations of channels 5 and 13 for reflected signals provide examples of this phenomenon. It is probable that this would only occur if a WECS were installed directly between a receiver and a transmitter. In most cases these effects could be eliminated by adjustment of antenna direction and position.

Although it is recognized that this investigation has been wholly qualitative, the observations do indicate that television interference effects in the immediate vicinity of a large vertical axis wind turbine with metal blades such as the Indal Technology's 500-kW machine need not be of great concern. It should also be considered as well that it is highly unlikely that many television viewers would reside as close to a wind turbine of the dimensions of the Indal 500 kW as the locations of the observations made during this investigation.

It may be useful to consider that the principal investigator resides only a few kilometers from the Atlantic Wind Test Site and that there are several other rural residences within 1 km of the machine, most of whom employ directional antennas of the type used in this investigation to obtain television reception. Enquiries made of residents during this investigation and occasionally throughout the five years that the Indal 500-kW wind turbine has been operating at the Site have revealed no indication that any problems with television reception have been experienced.

SOMMAIRE

L'analyse des observations révèle que l'éolienne entraîne bel et bien l'apparition d'images à trajet multiple, qui semblent être le résultat de reflets à trajet multiple. L'enregistrement des émissions du canal 5, aux points 4 et 6, ainsi que de celles du canal 13, aux points 5 et 6, en donne la preuve. Les pires interférences ont été notées uniquement lorsque l'antenne était orientée directement vers l'éolienne. L'observation des émissions des canaux 5 et 13, en vue de déceler la présence de signaux réfléchis, a été concluante à cet égard. Il est probable que ces interférences ne se produiraient que dans le cas d'un système de conversion de l'énergie éolienne aménagé directement entre un poste récepteur et une tour émettrice. Dans la plupart des cas, ces effets pourraient être éliminés en changeant l'orientation et l'emplacement de l'antenne.

Bien que l'on reconnaisse que cette étude a uniquement porté sur les aspects qualitatifs du problème, on a établit, à la suite des observations, qu'il ne fallait pas s'inquiéter outre mesure de l'interférence produite par une grande éolienne à axe vertical munie de pales métalliques, telle que l'éolienne (de 500 kW) d'Indal Technology. Il faut également tenir compte du fait que pour les besoins de l'étude, on a situé les points d'observation très près de l'éolienne, et qu'il est fort improbable qu'un grand nombre de téléspectateurs demeurent à une distance aussi courte d'une éolienne de dimension comparable à celle d'Indal (500 kW).

On peut également attacher de l'importance au fait que le directeur de cette étude ne demeure qu'à quelques kilomètres du Terrain d'essai éolien de l'Atlantique et que plusieurs autres maisons sont situées hors d'un rayon d'un kilomètre de l'éolienne. La plupart de ces maisons sont équipées d'antennes directionnelles du type utilisé aux fins de l'étude. D'après des enquêtes menées auprès des habitants de ce secteur pendant l'étude et avant celle-ci, aucun problème de réception ne s'est posé au cours des cinq années d'exploitation de l'éolienne Indal (500 kW).

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APPENDIX A

Field Observation Data Sheets

Data Sheet.

Date: July 8 1988 Time: 08:13 Location #: 2

Channel: 4 Weather: HAZY

Signal type: Test Pattern [✓]

Normal Program [ ] Name- _____

Best signal (RS):

CB 235° BTC 0706 ETC 0748 Start-T 08:13 Stop-T 08:15

COM Constant Good Quality Picture ; Definite low scale Ghosting (235°)

Interfered signal (NO):

CB 235° BTC 0748 ETC 0809

Start-T 08:47 Stop-T 08:50

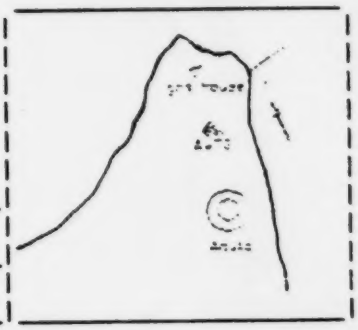
COM Definite Medium Scale Ghosting Constant Good Quality Picture

Highest interfered signal (NO):

CB _____ BTC 0748 ETC 0809

Start-T 08:47 Stop-T 08:50

COM _____

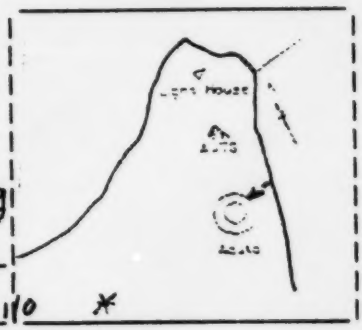


Reflected signal (NO):

CB 235° BTC 0748 ETC 0809

Start-T 08:47 Stop-T 08:50

COM Definite Medium Scale Ghosting Slight shift in Picture occurring at a rate of 2 times Per rev. of Aquilo *



Data Sheet.

Date: July 8 1988 Time: 08:15 Location #: 2

Channel: 13 Weather: Hazy

Signal type: Test Pattern [✓]

Normal Program [ ] Name-> _____

Best signal (RS):

CB 180° BTC 0801 ETC 0846 Start-T 08:15 Stop-T 08:18

COM Constant Quality Picture, low scale ghosting (180°)
Constant low Quality Picture, low (more defined) ghosting (235°)

Interfered signal (NO):

CB 180° BTC 0846 ETC 0913

Start-T 08:36 Stop-T 08:40

COM Constant Quality Picture
Definite low scale Ghosting

Highest interfered signal (NO):

CB 0° BTC 0834 ETC 0913

Start-T 08:36 Stop-T 08:40

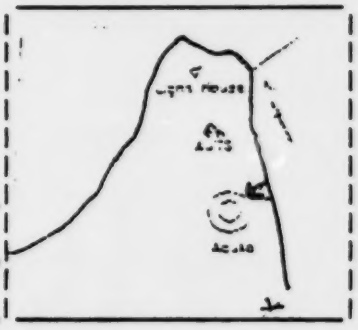
COM Greatest Ghosting occurs
Quality of Picture decreases

Reflected signal (NO):

CB 235° BTC 0846 ETC 0913

Start-T 08:36 Stop-T 08:40

COM Constant low Quality Picture
Definite low Scale Ghosting



Data Sheet.

Date: July 8/1988 Time: 08:20 Location #: 2

Channel: 5 Weather: Hazy

Signal type: Test Pattern [ ]

Normal Program [✓] Name-> Canada AM

Best signal (RS:):

CB 235° BTC 0771 ETC 0818 Start-T 08:20 Stop-T 08:22

COM Constant Quality Picture, Definite low scale Ghosting (235°)

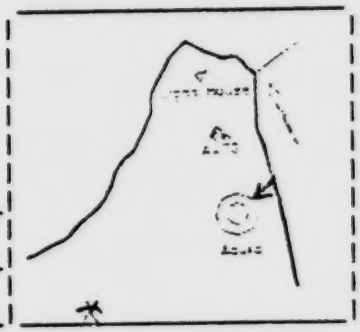
Interfered signal (NO):

CB 235° BTC 0818 ETC 0880

Start-T 08:32 Stop-T 08:35

COM Constant Quality Picture

Definite low scale Ghosting



Highest interfered signal (NO):

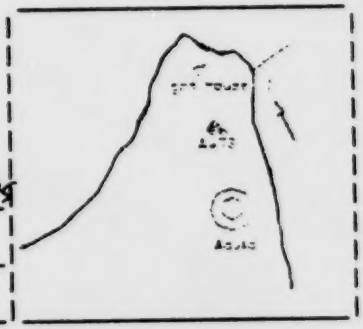
CB 0-360° BTC 0818 ETC 0880

Start-T 08:32 Stop-T 08:35

COM Quality of Picture decreases

as you turn the antenna

away from the 235° Bearing



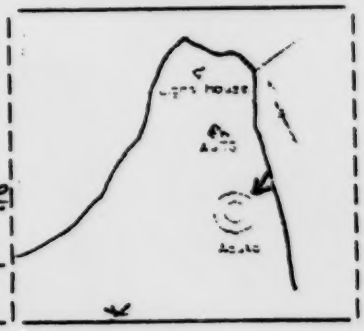
Reflected signal (NO):

CB 235° BTC 0818 ETC 0880

Start-T 0832 Stop-T 08:35

COM Constant Quality Picture

Definite low scale Ghosting



Data Sheet.

Date: July 8 1988 Time: 09:00 Location #: 3

Channel: 13 Weather: Hazy

Signal type: Test Pattern [4

Normal Program [ ] Name-> _____

Best signal (RS):

CB 180° BTC 0980 ETC 1022 Start-T 09:25 Stop-T 09:27

COM Constant Quality Picture low scale Ghosting (180°)
more defined lowscale Ghosting (300°)

Interfered signal (NO):

CB 180° BTC 0913 ETC 0980

Start-T 09:00 Stop-T 09:04

COM Definite medium Scale Ghosting
Constant Quality Picture

Highest interfered signal (NO):

CB 345°-350° BTC 0913 ETC 0980

Start-T 09:00 Stop-T 09:04

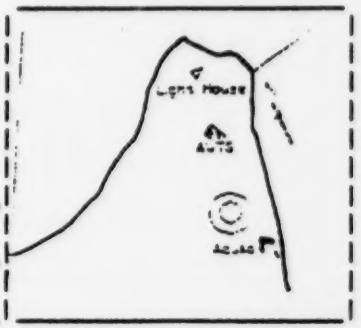
COM Greatest Ghosting occurs
Level of shifting decreases
but occurs at same rate as for
Reflected signal

Reflected signal (NO):

CB 300° BTC 0913 ETC 0980

Start-T 09:00 Stop-T 09:04

COM Shifting low Quality Picture
shifting occurs at a rate of
2 times per 1 rev of Aquilo



Data Sheet.

Date: July 8 1988 Time: 09:06 Location #: 5

Channel: 4 Weather: HAZY

Signal type: Test Pattern [✓]

Normal Program [ ] Name-> _____

Best signal (RS):

CB 235° BTC 0873 ETC 0910 Start-T 09:29 Stop-T 09:31

COM No signal available

Interfered signal (NO):

CB 235° BTC 0309 ETC 0873

Start-T 09:06 Stop-T 09:09

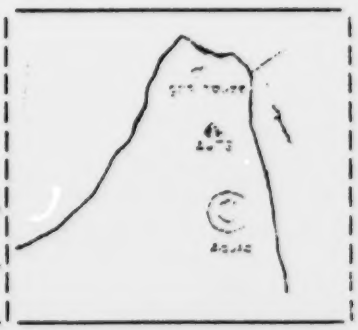
COM Constant Medium Quality signal Definite medium Scale Ghosting

Highest interfered signal (NO):

CB _____ BTC 0809 ETC 0873

Start-T 09:06 Stop-T 09:09

COM _____

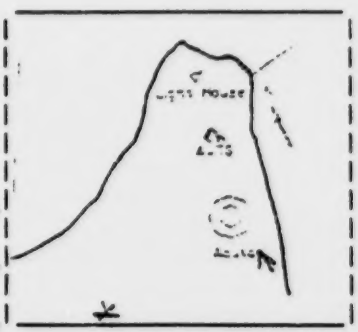


Reflected signal (NO):

CB 300° BTC 0809 ETC 0873

Start-T 09:06 Stop-T 09:09

COM Quality is too Poor to make any inferences



Data Sheet.

Date: July 8. 1988 Time: 09:12 Location #: 3

Channel: 5 Weather: Hazy

Signal type: Test Pattern [ ]

Normal Program [✓] Name-> CANADA AAL

Best signal (RS):

CB 235° BTC 0950 ETC 0989 Start-T 09:22 Stop-T 09:25

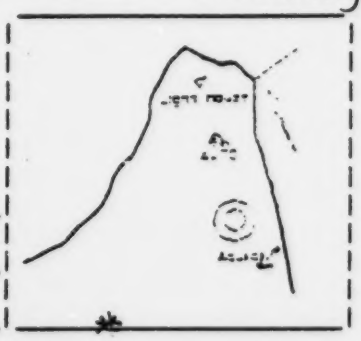
COM constant Quality Picture, low scale Ghosting (235°)
constant Quality Picture, increase in Ghosting (300

Interfered signal (NO):

CB 235° BTC 0930 ETC 0950

Start-T 09:13 Stop-T 09:15

COM Definite low scale Ghosting
Constant top Quality Picture



Highest interfered signal (NO):

CB 345°-N BTC 0870 ETC 0950

Start-T 09:13 Stop-T 09.15

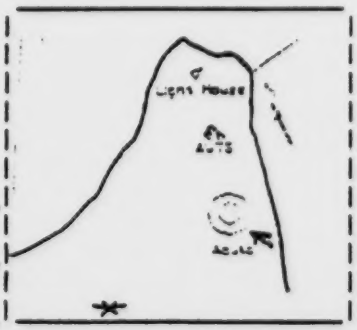
COM increase in ghosting
a flicker in the Picture but
not Pronounced enough to make
any inferences

Reflected signal (NO):

CB 300° BTC 0880 ETC 0950

Start-T 09:13 Stop-T 09:15

COM Slight increase in Ghosting
Constant lower Quality
Picture



Data Sheet.

Date: July 8 1988 Time: 09:48 Location #: 1

Channel: 4 Weather: over

Signal type: Test Pattern [X]

Normal Program [ ] Name _____

Best signal (RS):

CB 235° BTC 0910 ETC 0945 Start-T 09:45 Stop-T 09:50

COM No Reception

Interfered signal (NO):

CB 235° BTC 0945 ETC _____

Start-T _____ Stop-T _____

COM No Reception

Highest interfered signal (NO):

CB _____ BTC _____ ETC _____

Start-T _____ Stop-T _____

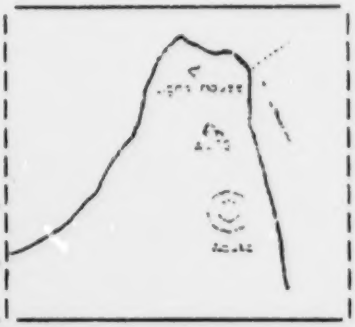
COM _____

Reflected signal (NO):

CB _____ BTC _____ ETC _____

Start-T _____ Stop-T _____

COM _____



Data Sheet.

Date: July 8, 1987 Time: 10:00 Location #: 1

Channel: 5 Weather: Hazy (clearing) 12-18m/s

Signal type: Test Pattern [ ]

Normal Program [X] Name-> Romper Room

Best signal (BS):

CB 235° BTC 1038 ETC 1060 Start-T 10:04 Stop-T 10:05

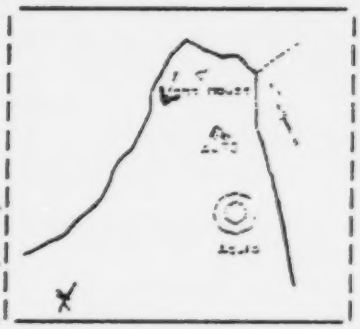
COM Definite low Scale Ghosting Constant medium quality Picture Constant Low Quality Picture at (180°)

Interfered signal (NO):

CB 235° BTC 0989 ETC 1038

Start-T 10:01 Stop-T 10:03

COM Definite low Scale Ghosting Constant medium Quality Picture.

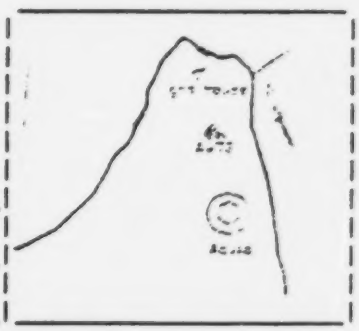


Highest interfered signal (NO):

CB None BTC 0989 ETC 038

Start-T 10:01 Stop-T 10:03

COM

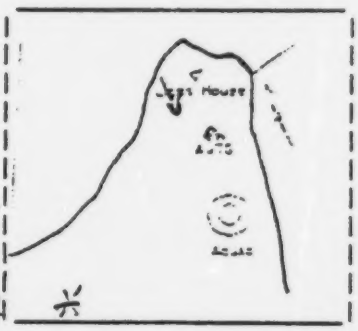


Reflected signal (NO):

CB 180° BTC 0989 ETC 1038

Start-T 10:01 Stop-T 10:03

COM Slight shifting occuring at a rate of 2 times per 1 rev. of aquilo. low Quality Picture large Scale Ghosting



Data Sheet.

Date: July 7, 1988 Time: 08:05 Location #: 5

Channel: 4 Weather: slightly overcast

Signal type: Test Pattern [X]

Normal Program [ ] Name-> ___

Best signal (RS):

CB 235 BTC 0411 ETC 0481 Start-T 08:05 Stop-T 08:05

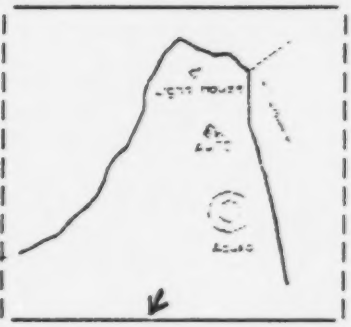
COM Constant medi Quality Signal Definite low scale Ghosting (235°)
Very Poor Quality Picture at (55°)

Interfered signal (NO):

CB 235° BTC 0481 ETC 0556

Start-T 08:36 Stop-T 08:39

COM Definite low Scale Ghosting
Constant medium Quality Picture

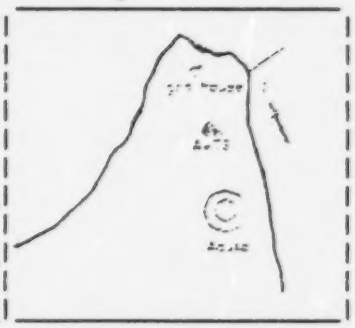


Highest interfered signal (NO):

CB ___ BTC 0481 ETC 0556

Start-T 08:36 Stop-T 08:39

COM ___

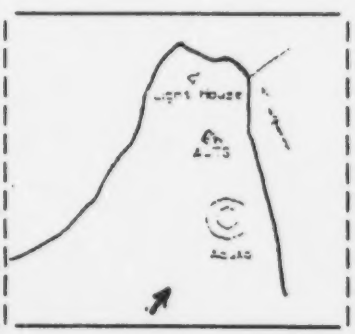


Reflected signal (NO):

CB 55° BTC 0481 ETC 0556

Start-T 08:36 Stop-T 08:39

COM Quality is too Poor to
make any Inferences



Data Sheet.

Date: July 7 1988 Time: 08:11 Location #: 5

Channel: 13 Weather: Slightly overcast

Signal type: Test Pattern [X]

Normal Program [ ] Name-> _____

Best signal (RS):

CB 180° BTC 0481 ETC 0546 Start-T 08:11 Stop-T 08:14

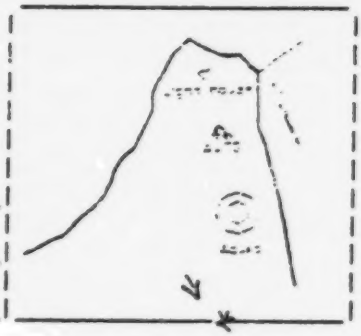
COM Definite low scale Ghosting (120°) very large Scale at (55°)

Interfered signal (NO):

CB 180° BTC 0546 ETC 0636

Start-T 08:29 Stop-T 08:33

COM Definite low scale Ghosting
Constant Quality Picture

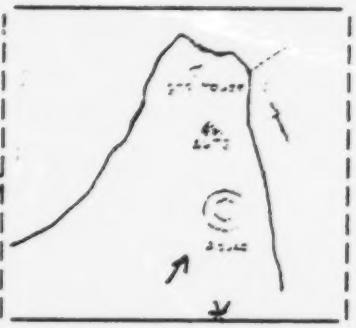


Highest interfered signal (NO):

CB 55° BTC 0546 ETC 0636

Start-T 08:29 Stop-T 08:33

COM highest interference occurs at 55°

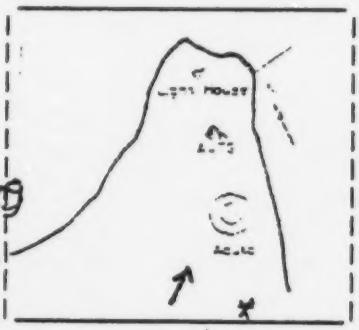


Reflected signal (NO):

CB 55° BTC 0546 ETC 0630

Start-T 08:29 Stop-T 08:33

COM Definite very large Scale Ghosting
A Definite shift from side to side of picture occuring 2 times per 1 rev of Aquilo.



Data Sheet.

Date: Tues = 15 Time: 08:15 Location #: 5

Channel: 5 Weather: Slight ov over cast

Signal type: Pattern [ ]

Normal Program [✓] Name-> CANADA (A)

Best signal (RS):

CB 235° BTC 0358 ETC 0460 Start-T 08:10 Stop-T 11:15

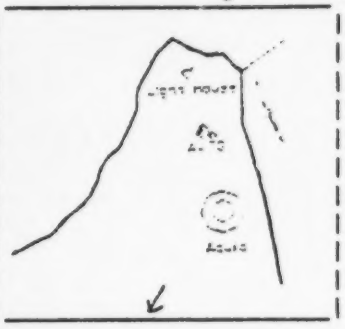
COM Constant Quality Picture Definite very low scale ghosting Definite very large scale Ghosting Constant Picture (55°) (235°)

Interfered signal (NO):

CB 235° BTC 0460 ETC 0544

Start-T 08:25 Stop-T 08:28

COM Constant top Quality Picture Definite very low scale ghosting

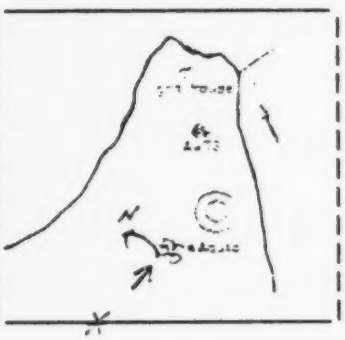


Highest interfered signal (NO):

CB 55°-N BTC 0460 ETC 0544

Start-T 08:25 Stop-T 08:28

COM Ghosting increases as you turn the Antenna North

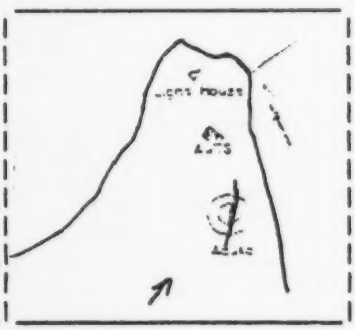


Reflected signal (NO):

CB 55° BTC 0460 ETC 0544

Start-T 08:25 Stop-T 08:28

COM Definite very large Ghosting Definite Twist in Picture from side to side occuring at a rate of 2 times per 1 rev of Aquila



Data Sheet.

Date: July 7 1988 Time: 09:02 Location #: 4

Channel: 13 Weather: Slightly overcast

Signal type: Test Pattern [X]

Normal Program [ ] Name-> _____

Best signal (BS):

CB 180° BTC 0636 ETC 0696 Start-T 09:08 Stop-T 09:05

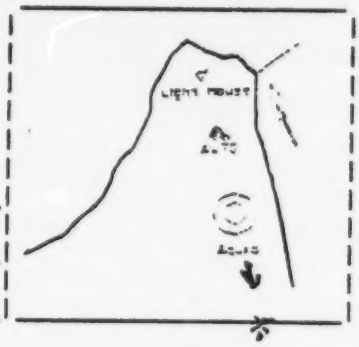
COM Constant Quality Picture 10% Scale Ghosting (180°)
Constant Poor Quality Picture large Scale Ghosting (345°)

Interfered signal (NO):

CB 180° BTC 0696 ETC 0801

Start-T 09:19 Stop-T 09:25

COM Constant Quality Picture
low Scale Ghosting

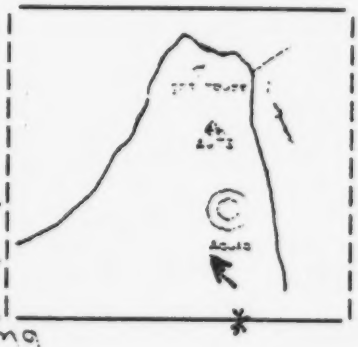


Highest interfered signal (NO):

CB 320° BTC 0696 ETC 0801

Start-T 09:19 Stop-T 09:25

COM Shifting low Quality Picture
Shifting occurs 2 times per
1 rev of AQuilo. Very large Scale
ghosting

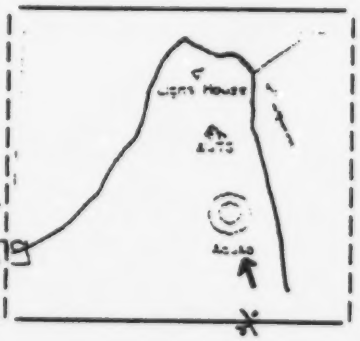


Reflected signal (NO):

CB 345° BTC 0696 ETC 0801

Start-T 09:19 Stop-T 09:25

COM Definite very large Scale Ghosting
Shifting motion in picture occuring
2 times per 1 rev. of Aquilo



Data Sheet.

Date: July 7 1988 Time: 09:07 Location #: 4

Channel: 4 Weather: Slightly overcast

Signal type: Test Pattern [ ]

Normal Program [ ] Name-> _____

Best signal (RS):

CB 235° BTC 0556 ETC 0627 Start-T 09:07 Stop-T 09:18

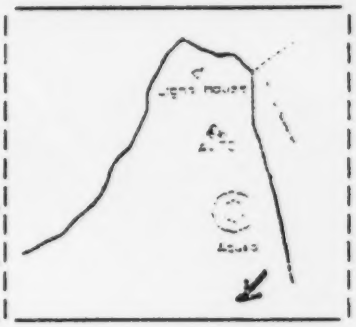
COM Constant medium Quality Picture. Some Ghosting
No Signal at (345°)

Interfered signal (NO):

CB 235° BTC 06:27 ETC 0706

Start-T 09:34 Stop-T 09:37

COM Definite medium Scale Ghosting
Constant medium Quality Picture

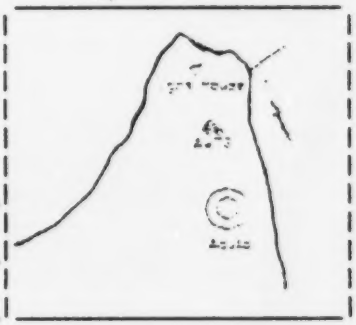


Highest interfered signal (NO):

CB _____ BTC 0627 ETC [illegible]

Start-T 09:34 Stop-T 09:37

COM _____

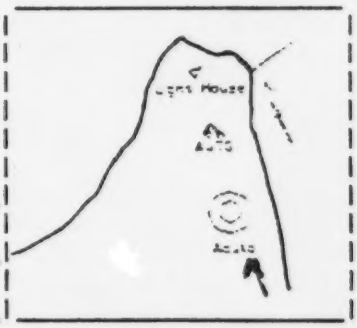


Reflected signal (NO):

CB 345° BTC 0627 ETC [illegible]

Start-T [illegible] Stop-T [illegible]

COM Receiving no Signal



Data Sheet.

Date: July 7, 1988 Time: 09:11 Location #: 4

Channel: 5 Weather: Slightly Overcast

Signal type: Test Pattern [ ]

Normal Program [✓] Name-> CANADA FM

Best signal (RS):

CB 235° BTC 0544 ETC 0621 Start-T 09:12 Stop-T 09:15

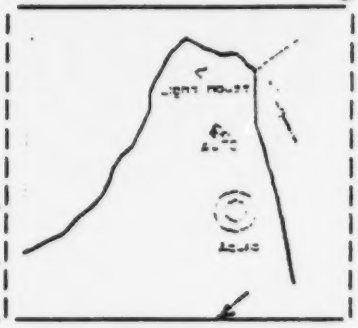
COM Constant Quality Picture Definite low Scale Ghosting (235°)
Constant low Quality Picture Definite large Scale Ghosting (345°)

Interfered signal (NO):

CB 235° BTC 0621 ETC 0771

Start-T 09:41 Stop-T 09:48

COM Constant Quality Picture
Definite Low Scale Ghosting



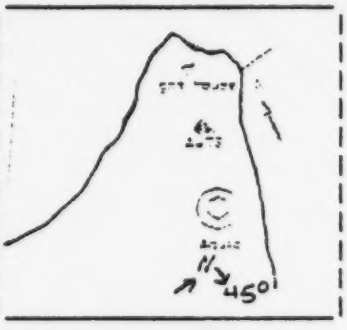
*

Highest interfered signal (NO):

CB N-45° BTC 0621 ETC 0771

Start-T 09:41 Stop-T 09:48

COM Shifting between more
Pronounced, Ghosting increases

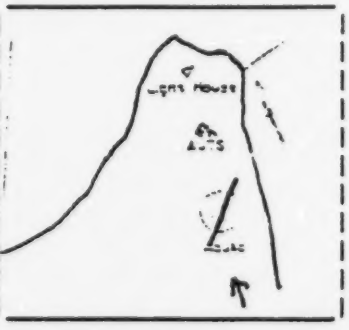


Reflected signal (NO):

CB 345° BTC 0621 ETC 0771

Start-T 09:41 Stop-T 09:48

COM Definite large Scale Ghosting
Definite Shift from side to side of
Picture occuring at a rate of 3 times
per 1 rev. of AQUILO



*

Data Sheet.

Date: July [illegible] Time: 03:20 Location #: 6

Channel: 4 Weather: Overcast

Signal type: Test Pattern [X]

Normal Program [ ] Name-> _____

Best signal (RS):

CB 335° BTC 0156 ETC 0276 Start-T 03:40 Stop-T 03:47

COM Shakey low Qvality Picture, Definite low Scale Ghosting

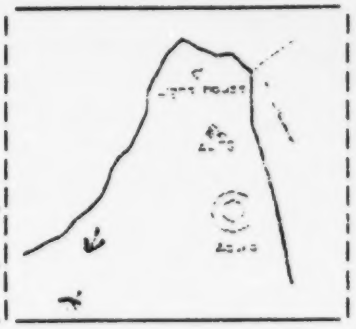
Interfered signal (NO):

CB 335° BTC 0000 ETC 0156

Start-T 07:22 Stop-T 07:29

COM Shakey Low Quality Picture

Definite low Scale Ghosting



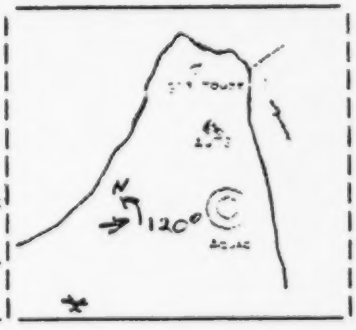
Highest interfered signal (NO):

CB Nomi° BTC 0000 ETC 0156

Start-T 07:22 Stop-T 08:29

COM Due to of signs increase

Ghosting increase



Reflected signal (NO):

CB 120° BTC 0000 ETC 0156

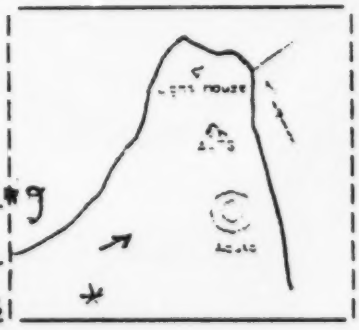
Start-T 03:22 Stop-T 03:29

COM Definite Very large Scale Ghosting

A shift from side to side of test

Pattern occuring at a rate of 2 times

per 1 rev. of Aquilo



Data Sheet.

Date: July 6 1988 Time: 8:30 Location #: 6

Channel: 13 Weather: overcast

Signal type: [ ] Test Pattern [X]

[ ] Normal Program [ ] Name-> _____

Best signal (RS):

CB 180° BTC 0150 ETC 0210 Start-T 08:36 Stop-T 08:39

COM Some ghosting, No shifting motion in picture

Interfered signal (NO):

CB 180° BTC 0000 ETC 0150

Start-T 08:30 Stop-T 08:34

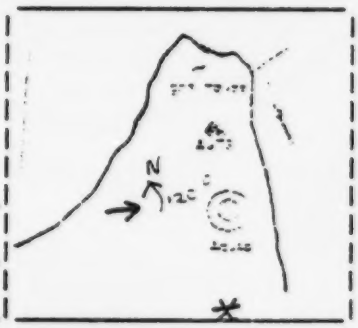
COM Ghosting (not as bad as for reflected signal). constant Quality Picture

Highest interfered signal (NO):

CB 180° BTC 0000 ETC 0150

Start-T 08:30 Stop-T 08:34

COM Larger Scale Ghosting Picture still shifts as for Reflected signal

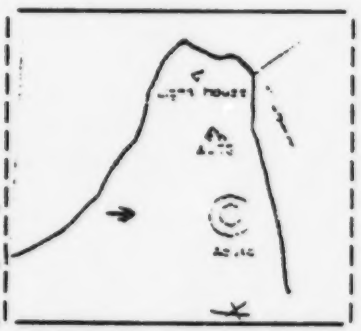


Reflected signal (NO):

CB 180° BTC 0000 ETC 0150

Start-T 08:30 Stop-T 08:34

COM Definite Ghosting Picture shifts on the screen a rate of 2 times Per 1 Rev of ant.



Data Sheet.

Date: [illegible] 1988 Time: 09:-- Location #: 7

Channel: 4 Weather: overcast

Signal Type: Test Pattern [X]

Normal Program [ ] Name-> _____

Best signal (RS):

CB 135° BTC 0300 ETC 041 Start-T 09:[illegible] Stop-T 09:35

COM Definite low Scale Ghosting (235°)
a jumpy low Quality Picture at (150°)

Interfered signal (NO):

CB 235° BTC 0276 ETC 0306

Start-T 09:08 Stop-T 09:11

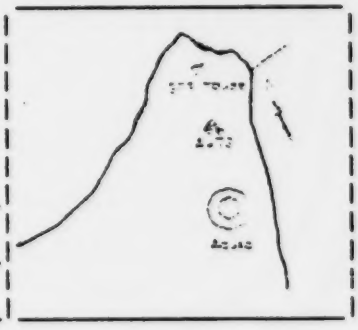
COM Definite low Scale Ghosting
Causes a jumpy low Quality Picture

Highest interfered signal (NO):

CB _____ BTC 0276 ETC 0366

Start-T 09:08 Stop-T 09:11

COM _____

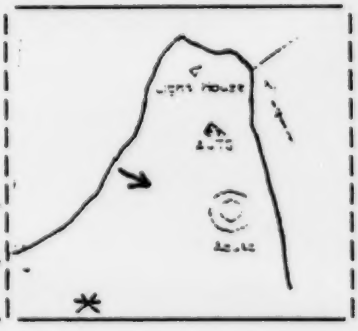


Reflected signal (NO):

CB 150° BTC 0276 ETC 0360

Start-T 09:08 Stop-T 09:11

COM Definite low Scale Ghosting
Shifting in two patterns
2 times per 1 rev. of Anvil



Data Sheet.

Date: Feb 6 1988 Time: 09:13 Location #: 2

Channel: 13 Weather: overcast

Signal type: Test Pattern [ ]

Normal Program [ ] Name-> _____

Best signal (RS):

CB 180° BTC 0322 ETC 0339 Start-T 09:36 Stop-T 09:53

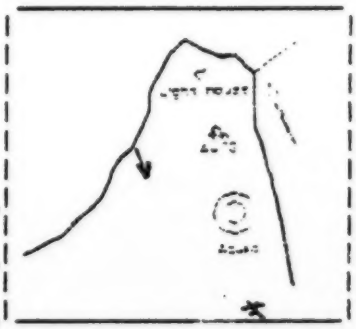
COM Low scale Ghosting (180°) large scale at (150°

Interfered signal (NO):

CB 150° BTC 0210 ETC 0322

Start-T 09:13 Stop-T 09:17

COM Definite low scale Ghosting
Constant Quality Picture

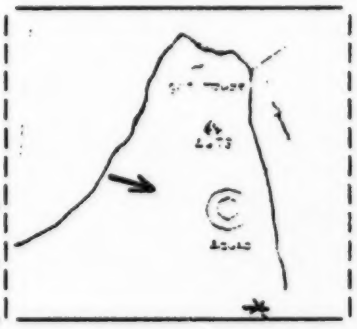


Highest interfered signal (NO):

CB 150° BTC 0210 ETC 0322

Start-T 09:13 Stop-T 09:18

COM _____

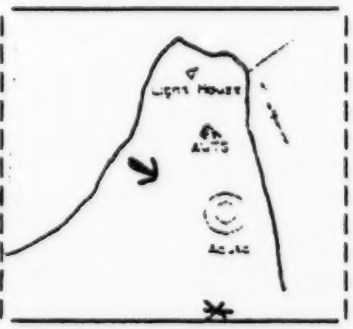


Reflected signal (NO):

CB 150° BTC 0210 ETC 0322

Start-T 09:13 Stop-T 09:18

COM Definite large scale Ghosting
Flicker and shifting motion in
Pictures occur 2 times per 1rev of
AQVILO.



Data Sheet.

Date: July 6, 1988 Time: 09:20 Location #: 7

Channel: 5 Weather: [illegible]

Signal type: Test Pattern [ ]

Normal Program [✓] Name-> [illegible]

Best signal (RS):

CB 235° BTC 0331 ETC 0392 Start-T 09:30 Stop-T 09:32

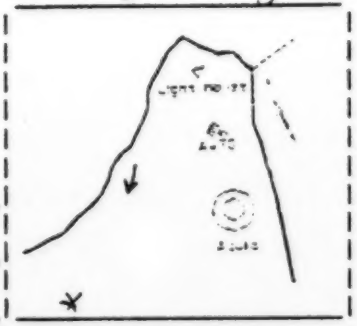
COM Constant top Quality Picture Very lonScale ghosting (235°)
Constant low quality picture large Scale ghosting (150°)

Interfered signal (NO):

CB 235° BTC 0238 ETC 0331

Start-T 09:21 Stop-T 09:24

COM [illegible] low Scale [illegible]
Constant top Quality Picture

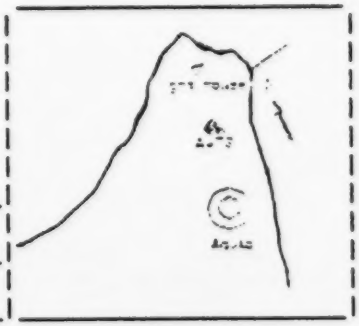


Highest interfered signal (NO):

CB _____ BTC 0238 ETC 0331

Start-T 09:21 Stop-T 09:24

COM _____

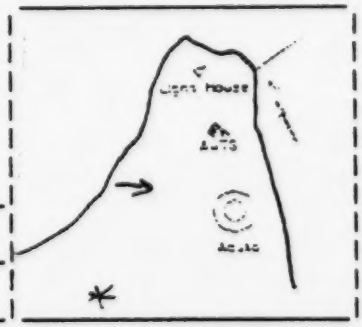


Reflected signal (NO):

CB 150° BTC 0238 ETC 0331

Start-T 09:21 Stop-T 09:24

COM Definite large Scale Ghosting
Definite flicker in Picture
occuring at a rate of 2 times per
1 rev. of Aquilo



Data Sheet.

Date: July 6 1988 Time: 09.51 Location #: 1

Channel: 13 Weather: Sunny to slightly overcast

Signal type: Test Pattern [✓]

Normal Program [ ] Name-> _____

Best signal (RS):

CB 180° BTC 0369 ETC 0400 Start-T 09:51 Stop-T 09:52

COM Definite low level Ghosting (180°)

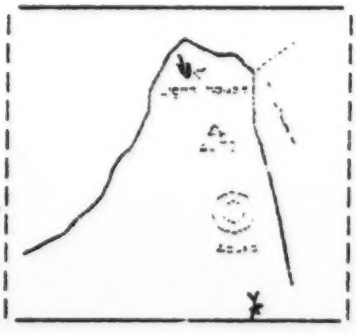
Interfered signal (NO):

CB 130° BTC 0400 ETC 0431

Start-T 09:52 Stop-T 09:56

COM low level Ghosting

Constant Quality Picture



Highest interfered signal (NO):

CB 50° BTC 0400 ETC 0431

Start-T 09:52 Stop-T 09:56

COM Quality of Picture decreases

Ghosting remains at same

Scale level.

Reflected signal (NO):

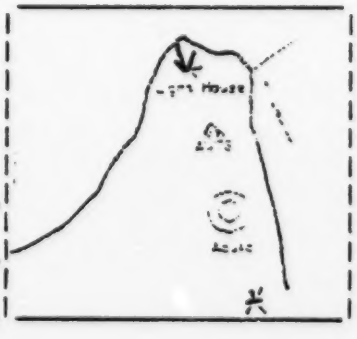
CB 130° BTC 0400 ETC 0431

Start-T 09:52 Stop-T 09:56

COM low level ghosting

Same comment as Interfered

signal



Data Sheet.

Date: July 5 1988 Time: 11:48 Location #: 6

Channel: 5 Weather: Sunny

Signal type: Test Pattern [ ]

Normal Program [✓] Name-> Definition

Best signal (RS):

CB 235° BTC 0173 ETC 0173 Start-T 11:56 Stop-T 11:59

COM Definite large scale ghosting (120°) constant Quality Picture Continuous Good Quality Picture Low ghosting (235°)

Interfered signal (NO):

CB 235° BTC 0000 ETC 0173

Start-T 11:53 Stop-T 11:56

COM Low Scale ghosting constant Good Quality Picture

Highest interfered signal (NO):

CB N-120° BTC 0000 ETC 0173

Start-T 11:53 Stop-T 11:56

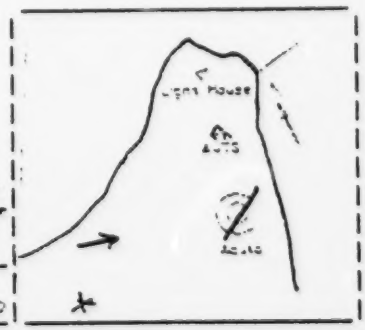
COM Greatest ghosting occurs shifting low Quality Picture

Reflected signal (NO):

CB 120° BTC 0000 ETC 0173

Start-T 11:53 Stop-T 11:56

COM Definite Very large Scale ghosting A shifting motion from side to side occurs 2 times per 1 rev of unit



APPENDIX B

Department of Communication
Summary Report of VITS Measurements

Government of Canada
Department of Communications

Gouvernement du Canada
Ministere des Communications

Your file Votre reference

Our file Notre reference

97 Queen Street
Charlottetown, P.E.I.
C1A 4A9

6154-1

Resource Ventures Inc.
P.O. Box 114
Charlottetown, P.E.I
C1A 7K7

July 16, 1988

Attention: Curtis Gavin

Curtis:

Please find the summary report of the measurements that were taken in North Cape on the 14th of July.

As discussed, the report is not highly technical because of our lack of tangeable measurements. However the subjective analysis and cursory measurements would indicate that there is not a great potential from a ghosting point of view. The potential for RFI/EMI is present but no greater than from the common hydro sub-station.

I've taken the liberty to include two (2) circulars on the subjects which may be of interest to you.

I hope that the accompanying report and circulars are to your satisfaction.

Respectfully,

R. Guerrette
District Director

encl.

Canada

TELEVISION GHOSTING MEASUREMENTS FROM "VERTICAL AXIS" WINDMILLS

Ghosting measurements were performed at the Atlantic wind test site in North Cape, P.E.I. on July 14, 1988. It was suspected at the time that the large "egg beater" or "vertical axis" windmills may cause objectionable distortion in the VHF television bands. These power generating mills are to be deployed in remote areas where television signals are sometimes beyond the protected grade "B" coverage of the transmitters and in low ambient noise (radio frequency) mainly due to the sheer remoteness from industrialized societies.

Testing was done with a HP8716 digital spectrum analyzer/plotter and VITS (vertical interval test signals) monitor. The antenna used is a Potomac FIM 71 tuned dipole at 25 feet AGL (above ground level).

Tests were performed with the subject in front of our antenna directly in line with the transmitter and then directly behind our receiving antennae again in line with the transmitter. Both measurements were attempted from within a thousand feet of the subject. Signal strengths of -30 to -35 dbm registered on the VITS monitor. The ground was flat and 2-4m above MSL (mean sea level).

We attempted to measure echo or delay of the 2T pulse on the VITS screen. Reflections, although present on the screen (video monitor) did not show up on the VITS as a time delay. An increase in VIT Amplitude was noticeable pulsing in synchronization with the rotation of the blades (45 RPM x 2 blades). RF levels varied by as much as 3db on the spectrum analyzer measuring the amplitude of the video carrier.

The subjective analysis was more conclusive then the technical approach. Some echo was present when the subject was stationary but it was not possible to determine if all the reflections were from the windmill or from other structures in the immediate vicinity. There seems to be a pulsating effect on both the luminance and the color sub-carrier while the subject is rotating. Also, a slight echo was present and varying when the subject was rotating.

From the subjective rather than quantitative measurements, one would conclude the following:

Severity of the reflection is proportional to;

A) Incident power (ERP and proximity) ie. incident vs reflection.

B) Location or angle of the receiving station with respect to subject is a major factor in the reception of the interfering signal.

C) Proper orientation of receiving antennae plays a major role in selecting the incident and rejecting the reflected.

Tests indicated that the "echo" or "reflection" from the "Vertical Axis" mills are noticeable but not objectionable for the following reasons;

1) The signal level (amplitude) of the reflected would probably be below threshold of the receiver (due to low incident power because of remote locations).

2) Close proximity to the windmill causes the delay to be so minute in time that the echo is barely perceptible.

3) If far removed from the structure, factor #1 above plays an even more important role in cancelling the reflected signal when pathloss is added to even further reduce the level of the reflected signal.

The structure itself seems to play more of a role in obstructing the incident or wanted signal rather than cause objectionable echo in the picture. Pulsating amplitudes, when the mill is in operation, affecting both luminance and color are slightly objectionable and occur mainly when the structure is directly in line between the receiver and the transmitter and only if the receiver is in close proximity to the structure.

In my opinion, one would be more concerned of RFI/EMI generated by the high voltages produced by the mills mainly due to the acceptable reception of weaker than grade "B" signal levels which is quite often the case in remote areas. Notwithstanding the above, the structures design combined with its most probable location (open areas without structures and low population density) contribute to it <u>not</u> being a major concern when dealing with broadcast reception in remote areas.